Clinical review

Recent developments in vitamin D deficiency and muscle weakness among elderly people

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Elderly people's liability to falls and fractures is increased by many factors, including visual impairment, neurological disorders, orthopaedic disabilities, and drug effects. In one study showing that more than a third of people aged over 65 fell each year, the main risk factor was muscle weakness.[1] Poor muscle strength and weakness may be associated with vitamin D deficiency, which is common among elderly people[2] because the capacity of the skin to synthesise the provitamin calcidiol (25-hydroxycholecalciferol) decreases with age. Serious deficiency of vitamin D is common among elderly housebound people in old people's homes, nursing homes, and long stay wards and has been identified as an important public health problem.[2–5] In this review I discuss recent developments in screening and treating vitamin D deficiency among elderly housebound people aimed at reducing the incidence of falls and fractures.

Recent developments

- The prevalence of vitamin D deficiency in elderly people is much greater than previously realised, especially among those who are housebound
- Vitamin D deficiency is associated with muscle weakness as well as osteomalacia
- Deficiency is also associated with falls and fractures among elderly people that are not explained by reduced bone density
- Supplementation of 800 IU of vitamin D daily is needed to have an effect on falls

Sources and selection criteria

This review is based on material identified through Medline searches and the author's personal library, and through discussions with researchers.

Evidence of association

Higher plasma concentrations of calcidiol are associated with muscle strength, physical activity, and ability to climb stairs and lower concentrations with falls among elderly people.[6 7] Indeed, in a randomised controlled trial elderly women given 800 IU vitamin D daily with calcium had a 47% reduction in falls and fractures compared with controls receiving calcium alone over 12 months.[8] In another trial with three month follow up, the incidence of falls was almost halved and musculoskeletal function improved among elderly people who had 800 IU vitamin D with calcium compared with calcium alone.[9]

Being housebound as a risk factor

The prevalence of falls at age 85 is double that at ages 65-75.[10] Most studies of osteoporosis among elderly people cover a wide age range and do not focus specifically on those who are housebound, despite the fact that age and being housebound are independently associated with vitamin D deficiency. Among the least disabled group in the Women's Health and Ageing Study, the frequency of severe vitamin D deficiency was 8.3% in those aged 65-74, 14.5% at ages 75-84, and 17.4% at 85 and over.[2]

This may not reflect cause and effect. Nevertheless, this phenomenon could be explained by reduced concentrations of 7-dehydrocholesterol, which is needed to synthesise calcidiol, in ageing skin.[5] And housebound elderly people often do not get adequate exposure to sunlight. They probably also get less exercise than other elderly people, and exercise training can reduce the incidence of falls.[11]

The best evidence for an association between deficiency and being housebound comes from a study in Finland. This found that mean plasma calcidiol concentrations were low among people over 85 living in their own homes but even lower among people aged 75-84 living in old people's homes.[12] Other studies in a long stay geriatric ward[13] and in nursing and residential homes, which excluded patients with osteomalacia, confirm the association.[14 15] There are other associations as well as age and housebound status: the prevalence of vitamin D deficiency is ten times higher in African-American than in white women in America,[16] and deficiency seems to be more common in Europe than in the United States.[17 18]

Problem of inadequate doses

If vitamin D deficiency is associated with musculoskeletal weakness and falls among elderly people, why does supplementation with the vitamin sometimes fail to help? The explanation seems to be inadequate

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Scanning electron micrograph of skeletal muscle fibres

dose. Two randomised controlled trials have found 400 IU/day of vitamin D to be ineffective in reducing the frequency of fractures,[15 19] and two descriptive studies have noted deficiency despite supplementation at a dose of 400 IU daily.[13 14] Furthermore, one trial of high dose treatment showed no evidence of reduction in falls among frail outpatients.[20] But vitamin D deficiency is only one risk factor for falls and fractures among elderly people, and in this study the patients who received placebo had near normal mean calcidiol concentrations and still had a high frequency of falls, probably because they had other disabilities that were not amenable to vitamin D treatment.

In contrast, five randomised controlled trials have shown that 800 IU/day of vitamin D significantly reduces the incidence of falls[8 9] and fractures.[21 22] The fifth trial showed a reduction in fractures using 100 000 IU of vitamin D every four months (a dose equivalent to 800 IU/day).[23] These high dose studies strengthen the evidence for and the public health importance of preventive treatment with adequate doses of vitamin D among housebound elderly people and suggest priorities for future research. But are there enough data on the safety of high dose vitamin D?

Safety of high dose supplementation

Vitamin D is usually given in the form of cholecalciferol. A comprehensive review article of data on toxic hypocalcaemia during vitamin D therapy for a variety of conditions found that the lowest level at which an adverse effect was observed was a serum calcidiol concentration of 200 nmol/l, corresponding to a daily intake of 40 000 IU.[24] A dose of 800 IU daily (or 100 000 IU three times a year) therefore has a 50-fold margin of safety. That review was primarily concerned with establishing the safe upper limit for daily dose but also included data on the safety of very large single doses up to 600 000 IU. In 3443 patients closely observed in clinical trials, no adverse effects occurred at a dose of 800 IU daily or 100 000 IU at various intervals.

Although administration of 800 IU of cholecalciferol to residents of old people's homes is safe, it is important to remember that cholecalciferol is ineffective in patients with renal or hepatic failure. The kidney is involved in the first step in metabolism of cholecalciferol to calcidiol, the form in which it is stored, and the liver in the final conversion to the active hormone calcitriol. For this reason patients with kidney or liver disease require treatment with calcitriol rather than cholecalciferol.

Conclusion

Vitamin D deficiency among elderly people is much more common than previously recognised. It constitutes a serious public health problem for residents of old people's homes, nursing homes, and long stay wards and housebound people in the community. The consequences include muscle weakness, body sway, and a tendency to falls and fractures, as well as osteomalacia.

Exercise is one evidence based approach to preventing falls, but not all elderly people are able to access or take up exercise training owing to disability and other factors. Treating elderly housebound people with 800 IU daily of vitamin D (or equivalent, such as 100 000 IU every 4 months) should also be seriously considered.[23] But the research on this so far has been carried out with cholecalciferol, which is not available in the United Kingdom except as 400 IU tablets with added calcium. Some patients find this awkward to take. Vitamin D_2 (ergocalciferol) is available at a dose of

Further educational resources

For doctors

- Vitamin D and lower-extremity function in the elderly. *Bandolier*. www.jr2.ox.ac.uk/bandolier/booth/Arthritis/VDmusceld.html (accessed 1 Feb 2005)
- Janssen HC, Samson MM, Verhaar HJ. Vitamin D deficiency, muscle function, and falls in elderly people. *Am J Clin Nutr* 2002;75:611-5
- Compston JE. Vitamin D deficiency: time for action. *BMJ* 1998;317:1466-7
- Grant WB. Vitamin D largely overlooked in review of interventions for the prevention of falls in older adults. Rapid response 19 Mar 2004 http://bmj.bmjjournals.com/cgi/eletters/328/7441/680#53950

For patients

- Health and Age. *The role of vitamin D in preserving muscle strength in seniors*. www.healthandage.com/PHome/gm=20!gid2=1826 (accessed 1 Feb 2005)
- Looksmart. *Vitamin D's muscle-strengthening effect and fracture prevention*. www.findarticles.com/p/articles/mi_m0815/is_6_29/ai_n6134289 (accessed 1 Feb 2005)

50 000 IU, which could be taken once every two months to provide an equivalent dose, but this needs testing in clinical trials.

The question of whether to treat all elderly people living in the community is problematic. Two thirds are not deficient in vitamin D, yet 250 would need to be treated for one year to prevent a fracture.[23] This number could probably be reduced by confining treatment to people aged 80 or older.[2] Treating only women with known vitamin D deficiency could prevent one fall for every five women treated for a year[8] and treating 20-25 women in nursing homes and old people's homes for a year without screening for vitamin D status would prevent one fracture.[21]

Finally, devotees of anecdote based medicine who need an example of the dramatic effect of vitamin D on muscle weakness (in a different clinical context) may wish to note the case report of "A woman who left her wheelchair" after three weeks of calcitriol for extremely severe vitamin D deficiency with progressive muscular weakness.[25]

I thank Richard Doll and Larry Ramsay for encouraging me to undertake this review.

Competing interests: GV is a semiretired independent consultant in pharmaceutical medicine. He spent most of his working life in the industry with responsibility for the clinical development of new drugs. He also worked as a medical assessor with the Committee on Safety of Medicines responsible for evaluating the efficacy and safety of new drugs. The review was prompted after participating in a five year randomised controlled trial of vitamin D for the prevention of fractures in elderly people by the realisation that appropriate preparations of vitamin D are not readily available in England.

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The power of prayer (and adequate fluid resuscitation)

While working in South Africa, 10 years ago, I visited a small town on the edge of the Little Karoo. This is a remote arid area of thorn bushes, ostriches, and minimal rainfall, but the town, Montagu, is famous for the production of muscatel, a sweet dessert wine.

In the past, the town's isolation resulted in its inhabitants being self sufficient. For medical care, they relied on the plant lore and skills of local healers. Recently botanists have started to identify the plants they collected and to document how they were used in remedies, which may lead to future research into plant derived cures. When I visited, orthodox medical care was available, but the town was still rather off the beaten track.

After a restful night, I was the only customer for breakfast in the small restaurant. As I waited for my meal, I examined the décor, which resembled an old fashioned tea room. Prominently displayed on one wall was a deep picture frame containing a statue of the Virgin Mary, encircled by a narrow blue plastic tube which looked vaguely familiar. On closer inspection, I realised to my amazement that it was a double lumen central venous catheter.

It seemed an unlikely place to find specialist medical equipment, and so I asked the waitress about it. Her face broke into a wonderful smile. Everyone had thought the owner of the restaurant was going to die when he was taken off to hospital with a burst appendix, he was so ill. But, praise be, he had started to improve after the doctors inserted the blue tube into the side of his neck. Our Lady had answered the people's prayers and saved his life.

The surgery he underwent and the antibiotics he must have received did not feature in the story of this miraculous recovery. Before the owner left hospital his family asked if they might keep the lifesaving tube. So now the double lumen central venous catheter hangs in a place of honour in a rural restaurant with a statue of the virgin—an instrument of divine, rather than medical, intervention.

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